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New Approach to Generic Attributes

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Abstract. Generic Attributes (GAs) are measures of process performance introduced by the systems engineering capability model, EIA/IS 731. The systems model defines two GAs – Effectiveness and Value. While the concept of GAs is generally accepted as valid, they have been used very little, due to difficulties in interpretation and appraisal.

Revised definitions and a new approach for appraising and using GAs have been developed for the Federal Aviation Administration Integrated Capability Maturity Model® v2.0 (FAA-iCMM®). The improved approach to Generic Attributes provides the needed clarity and measurement objectivity. Definitions of the iCMM GAs and their relationship to process model concepts are described, along with a practical approach to appraising GAs.

INTRODUCTION

The Need for Generic Attributes. Although capability and maturity levels indicate the level of process discipline that organizational units may achieve in one or more process areas, the levels do not necessarily translate into work products or results that meet objectives. It is possible to have mature processes (e.g., capability level 3, 4, or 5) that produce unsatisfactory work products (e.g., of less than desirable quality, or that do not meet needs, for greater than expected expense). In such cases, enhanced process capability may not result in the actual performance improvements that organizations expect from pursuing process improvement. This critical feature has not heretofore been measured via traditional appraisals.

GAs Introduced by EIA/IS 731. These concerns led the authors of EIA/IS 731 (EIA/IS 731, 1998) to define GAs and incorporate them into the appraisal process. While the need for GAs (as defined by EIA/IS 731) was widely acknowledged by the process improvement and appraisal community, operational difficulties have prevented their widespread use. EIA/IS 731 defined a Value GA and an Effectiveness GA and provided high-level definitions for 5 levels of each GA. The terms used by EIA/IS 731 to characterize the Value GA included: "desirability", "value", "benefit", "usefulness" and "utility". Terms and concepts used to characterize the Effectiveness GA include: "benefits received for the effort invested", "..benefits received worth the cost of the effort..", "..activities provide a reasonable benefit..", "..obviously beneficial....", "..maximum benefit for the amount of effort.." The 5 level rating scale was designed for use in ratings and comprised the levels of Marginal, Adequate, Significant, Measurably Significant, and Optimal".

Improvements Needed for GAs. The following issues were raised (by both GA advocates and detractors):

- The Effectiveness GA is difficult to understand; some of its levels read like "return on investment" while other levels seem to be almost the same as the Value GA.
- Respondents to GA questionnaires neither understand the GAs nor have a conceptual basis for an answer.
- There are no guidelines or objective evidence examples that would provide a basis for a respondent's answer; thus answers are highly subjective (leading to appraisal results that are not repeatable)
- GAs should not be used to determine process

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capability or maturity ratings; they represent a different dimension.

Broad Expression of Interest in GAs. In spite of the practical problems, GAs (like an idea whose time has come) "refuse to go away". Continued interest in GA-like concepts continues to be expressed, as indicated in the following work:

- ISO 9004 (ISO 9004, 2000) suggests consideration of self-assessment output together with the potential benefits to be gained for each process.
- ISO/IEC TR 15504-7:1998(E) (ISO/IEC TR 15504, 1998) describes effectiveness measures as: "the extent to which the software process achieves goals derived directly from an analysis of specific circumstances, needs and business goals of the organization."
- "An Empirical Methodology for Introducing Software Processes" (Shull, et.al 2001]) In section 3.1, "Did the process provide Useable Results", the authors discuss feasibility studies to test the effectiveness (did the process provide useable results ?) of a process. In the following section, "Was the time well spent", the authors discuss the determination of whether the return on investment is reasonable.

Achieving a Workable Approach to GAs. FAA iCMM V2 (Ibrahim, et. al., 2001) builds on, and extends, EIA/IS 731 and the above work to describe a practical approach to the use of Generic Attributes. The iCMM V2 approach recognizes that GAs are not a factor in process capability/maturity, but are indeed a different dimension that can be used to confirm the effectiveness of process capability/maturity measurements and prioritize improvement areas. Objectivity in GA measurements is obtained by providing clear definitions of the GAs and by establishing an appraisal method that:

- Identifies and focuses on key results of process areas for GA measurements
- Identifies and distinguishes between "developers" and "users" of the key results
- Asks appropriate questions of developers (e.g, cost of developing the key result)
- Asks appropriate questions of users (e.g., on usefulness of results and needs satisfaction)
- Identifies and examines objective evidence to corroborate developer and user inputs

DESCRIPTION OF FAA-ICMM V2 GENERIC ATTRIBUTES

Generic Attributes are a way of measuring two characteristics of process performance results: Usefulness and Cost Effectiveness. The Usefulness Generic Attribute indicates the traditional sense of usefulness or value of the products or results of performing processes relating to a process area. The Cost Effectiveness Generic Attribute indicates the extent to which the benefit received is worth the resources invested in producing the products or results.

These two characteristics of process performance were chosen because they represent key issues in organizational improvement. They help an organization address the bottom-line questions such as: Are our processes resulting in useful results in relation to our business objectives? Are we spending our resources wisely? Are we actually improving? Are our processes more effective? Are we being efficient? Do we need further improvement?" Generic Attributes are measured on a different scale from process capability and maturity and are not considered in the determination of process capability or maturity level. They are valuable as an independent check on the alignment of process capability and process performance. They do however presume that a specific described process is being followed in order to come up with the results that are measured by Generic Attributes. Then, if GAs have low scores for a process area that is relatively high in process capability, the improvement practices being performed at that capability level may not actually be effective, and this would suggest an important improvement path for the organization to investigate.

Alternatively, if GA scores are acceptable from a business perspective for a process area, further improvement in the process area may not be a high priority. The trend of GA scores for process areas of constant capability level may also yield useful information about process improvement methods and priorities. Other useful enquiries based on GAs are: is there a difference in the perceptions of Usefulness when viewed across an organization? ...between perceptions of Cost Effectiveness? Why? The collection of GA data on a given process area begins with determination of the key services or products that result from the process. This is called the Key Result(s) for a GA appraisal. The Key Result is the focus of GA appraisal data collection. Interviews and objective evidence review focus on the Key Result(s).

THE USEFULNESS GA

Defining Usefulness. Usefulness is defined as: *the extent to which work products or services provide the*

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needed benefits in actual use.

Usefulness is determined for the Key Result(s) as indicated in Table 1. In the table, interpret "meet the need" based on the process area and Key Result(s). Process area purpose, goals, and typical work products can be used as starting points to identify the Key Result(s).

Usefulness	The benefits of the work products or results of performing a process
U++	significantly exceed the need
U +	exceed the need to some degree
U	meet the need
U-	are somewhat lacking in meeting the need
U--	are substantially deficient in meeting the need

Table 1: Usefulness Generic Attribute

Sources of Usefulness Data. Usefulness data is obtained primarily from interviewing users of the Key Results and from review of related objective evidence. Objective evidence may come from verification or validation evaluations of Key Result(s). GA review of evaluation objective evidence would consider characteristics of the results (e.g, number of defects); in contrast with objective evidence review for process appraisals, which considers only the existence of results. The concepts of Key Result(s), identification of users as the "authority" on their usefulness, and identification of categories of Key Result(s)/user objective evidence represent "breakthroughs" for practical and objective GA appraisals.

Scoring the Usefulness GA. A Usefulness score of "U" indicates that there were no deficiencies in the Key Result(s) with respect to meeting the need. U- indicates that there were some deficiencies, and U-- indicates significant deficiencies. U+ indicates the Key Result(s) somewhat exceeded its need, and U++ indicates that the needs were significantly exceeded. Projects should usually pursue Usefulness with caution, as exceeding expectations may result in unnecessary expense (lowered Cost Effectiveness). The Usefulness Generic Attribute is closely related to validation of incremental work products described in the iCMM V2 Evaluation Process Area (PA 08). The process area describes evaluations, including validation of the work products or services of a process, to determine *whether* they satisfy their need. The measurement of the Usefulness GA is very similar to validation of a product or service component but it additionally measures *the extent* to which the need is satisfied. A process (appraisal method) for objectively measuring Usefulness is further described in the following section of the paper.

THE COST EFFECTIVENESS GA

Defining Cost Effectiveness. Cost effectiveness is defined as: *the extent to which the benefits received are worth the resources invested.* Cost effectiveness is determined through the use of an intermediate parameter – "Resource Efficiency".

Resource Efficiency. Resource efficiency is the deviation of the actual resources required to produce the Key Result(s) from the benchmarked (expected) value of needed resources.

The reference or target for resource investment for a given work product or result is the benchmarked standard. If actual benchmark values are not available, other credible reference values may be used – e.g., a value supported by a planning estimate. In order to determine Cost Effectiveness, the Resource Efficiency is first determined as indicated in Table 2.

Resource Efficiency	Resources expended to produce the work product(s) or result(s)*
E++	were less than the expected (benchmarked) values by more than 50%
E+	were less than the expected (benchmarked) values by 5% to 50%
E	were within 5% of the expected (benchmarked) values
E-	were more than the expected (benchmarked) values by 5% to 50%
E--	exceeded the expected (benchmarked) values by more than 50%

* The exact percentages can be tailored by the organization

Table 2: Resource Efficiency

Key to improving GA appraisal objectivity for Cost Effectiveness, in addition to focusing on Key Result(s), is the recognition that Key Result(s) developers and their supporting objective evidence are

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the "authority" on resource efficiency. The personnel assigning values in the above table are knowledgeable of the resource planning and expenditures relating to the identified work products or results, in contrast to the personnel making inputs on the Usefulness, who were the users of the products or services. Types of objective evidence for Resource Efficiency would include benchmark cost (or other cost basis) and actual cost related to development of the Key Result(s).

An organization or enterprise can tailor the GAs based on the type and availability of data or to meet its unique needs. For example, it could set its own percentages or other criteria for measuring the Resource Efficiency or use only three levels (e.g., E, E+, and E-). Tailoring does not preclude the use of GAs for benchmarking; it just restricts benchmarking to the organization or enterprise that defines the tailoring.

Determining Cost Effectiveness. Once the resource efficiency is determined, the Cost Effectiveness is represented according to the graph in Figure 1.

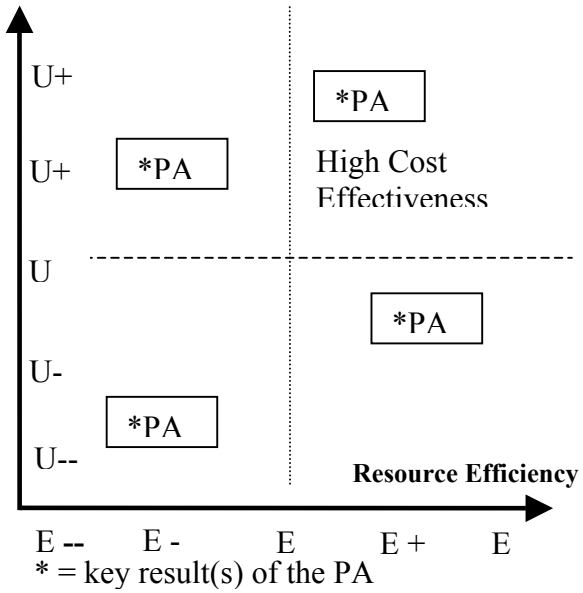

Figure 1. Cost Effectiveness

The figure illustrates GA plots for example process areas (PAs). Key Results in the upper right quadrant, having both high Usefulness and high Resource Efficiency, are clearly highly Cost Effective. The lower left quadrant represents low Cost Effectiveness. The other two quadrants represent intermediate Cost Effectiveness; any degree of Cost Effectiveness in which the Usefulness is below some threshold could be considered unacceptable.

GA APPRAISAL PROCESS

The GA appraisal process involves the following steps.

- Select a process area for GA appraisal
- Determine the primary output/result(s) (Key Results) of the selected process area.
- Identify the process that produces the Key Results and the lead and staff for the process.
- Identify the process that uses the Key Results and the lead and staff for the process.
- Collect data on the Usefulness GA from key result users.
- Collect data on the Resource Efficiency parameter from key result producers
- Score the GAs based on the collected data and the GA definitions.

Identifying Process Results for GA Appraisals. Generic Attributes measure characteristics of the outputs or results from performing a process. The FAA-iCMM v2.0 model description helps the organization in identify what results might be measured during a GA appraisal. For example, FAA-iCMM process area descriptions include a purpose, goals, essential base practices for attaining the purpose or achieving the goals, and example practice outputs or results that might be expected. Such work products (possible Key Result(s)) may include documents, services, or processes such as a training process; example outcomes might be expressed in the PA purpose or goals. Understanding the purpose, goals, and practices of a process helps in determining the Key Result(s) (e.g., what results might be expected and appraised by means of GAs). Examples indicating work products (Key Results), potential users and anticipated needs are shown in Table 3. A GA appraisal might ask users if these needs were being met as a result of using the outputs of the process.

Process Area (and selected work products)	**User of work products**	**User Needs** (outcomes and results)
Integrated Enterprise Management – vision, goals, values, projects	Enterprise managers, employees, project managers	Advance the business, clarity of purpose
Project Management – plans, direction, assignments, corrective action	Customer, project team	Objectives met, services delivered, tasks accomplished

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Process Area (and selected work products)	**User of work products**	**User Needs** (outcomes and results)
Needs – statement of need, operational concept, customer satisfaction levels	Customer, requirements developer, evaluator (validator)	Needs identified -basis for requirements, basis for validation, customer satisfied
Evaluation – evaluation reports, defects, recommended actions	Project manager, customer, developer	Defects removed
Operation and support – instructions, replaced elements	Product or service user	Sustained product or service performance
Measurement and Analysis – measures, values, trends, analysis results	Decision maker, manager	Fact-based decisions, quantitative understanding of performance
Training – courses, learning opportunities	People	Skilled people

Table 3: Sample Processes, Outputs, Users and Needs

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The appraisal data collection task then, is to determine how well the key result(s) met the need (Usefulness GA) and the extent to which the cost of producing the key result correlates to what it "should cost" (Resource Efficiency). Ideally the "should cost" comes from benchmarking. When benchmarking data are not available, historically based planning data can be used. Determination of the Usefulness GA and the Resource Efficiency parameter allow the Cost Effectiveness GA to be determined.

One aspect of improving objectivity in GA measurements is the recognition that Usefulness and Resource Efficiency data typically come from two different groups of project staff. Users of the key results tend to be the authoritative source of data on Usefulness, while producers of key results tend to be the authoritative source of data on Resource Efficiency.

Key Result Producers. Interviews of key result producers focus on the following questions:

- Please describe the benchmark data used to plan development of the Key Result(s)
- How did the actual cost of development compare with benchmark data ?
- Please describe the results of any reviews of the key results and any rework required or issues.

Key Result Users. Questions asked of key results users are:

- Please describe how the Key Result was used.
- Were there any issues associate with use of the key results ? .. any unexpected problems ? any unexpected benefits ?

Improving Objectivity. Another aspect of improving objectivity is obtaining quantitative data to support the GA determinations. Objective evidence is requested to support each interview question.

Benchmarked cost and the amount of rework (required to meet the need) can be quantitatively tied to Resource Efficiency and operational deficiencies or benefits can be quantitatively tied to the Usefulness GA.

AUGMENTING PROCESS APPRAISALS

Current Methods. Current process appraisal methods, including the FAA-iCMM Appraisal Method (FAM) version 1.0 (Ibrahim, et.al., 1999), focus on assessing the capability and maturity of the processes. These methods focus on reasonableness of the process and do not evaluate the Usefulness and Cost Effectiveness of the results of a process. The FAM defines a formal full robust process appraisal methodology along with five variations that all follow this focus. It is planned that the GA appraisal method will be added to the FAM as an additional variation to provide an optional way of evaluating Usefulness and Cost Effectiveness of the process results.

The FAM allows for combining, tailoring, and augmenting the different appraisal types. This means that the GA appraisal may be performed by itself or as part of a process appraisal depending on the sponsor's goals for an appraisal.

Opportunities to Use GAs. Generic Attributes can augment process improvement in the following ways:

- If an organization has recently performed a process appraisal, or would like to better understand a product/service result that is not related to an FAA-iCMM process area they have been currently pursuing, a standalone GA appraisal may be required.
- If an organization is just starting out with process improvement a variation of the FAM may be used to focus on initial, high-level, issues that the organization needs to focus on. In addition a GA appraisal may be used to develop baseline measurements.
- If an organization has been doing process improvement for some time and would like to have a formal FAM to verify that they have achieved a capability or maturity level, a GA appraisal may be used to additionally determine the efficiency and effectiveness of a process. If other GA appraisals have been done for an organization in the past, the trend and correlation between the process improvement and its effects on the product/service can be observed. (Note: the real power of the GA appraisal is realized when its results are compared with process appraisal results and trends are established.)

Integrating GAs into Appraisals. It is simple to integrate the process appraisal and the GA appraisal. Both types of appraisals interview people and review documents. In most cases they are talking to the same people and looking at the same documents, just from different perspectives. By adding one or two people to the process appraisal team whose role is to focus on the GA appraisal, they can use the existing appraisal Process Area focused mini-teams to help with document review and providing the correlation of the process to GA attributes.

PILOTING GENERIC ATTRIBUTES

Planning is underway to evaluate the appraisal method for Generic Attributes through a series of pilots

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beginning in the forth quarter of 2002. The first pilot will involve appraisal of the Usefulness GA for Risk Management. In meetings with the appraisal sponsors, several Risk Management outcomes were considered as possible Key Results that could be used as a focus for the appraisal. These were:

- the extent to which unanticipated events affected the projects performance (Relates to the overall usefulness of the risk management program)
- the fraction of adverse project events that were not identified as risks during risk identification activities. (relates to the usefulness of the risk identification activities)
- the fraction of "High" risk items whose level of risk was reduced to "Low" within the planned time frame. (Relates to usefulness of the risk mitigation activities)

The fraction of risk items reduced from high to low risk was selected as the Usefulness Key Result to be measured in the first pilot because of the availability of objective data and the value of the appraisal data to the sponsor and projects. Results of piloting the Generic Attributes will be reported in a future paper.

SUMMARY AND CONCLUSIONS

The FAA, with the iCMM V2, is piloting a new approach for appraising process performance via Generic Attributes. The FAA invites, and strongly encourages, other organizations experimenting with these concepts to contact the authors regarding their ideas and experiences. This is an idea whose time has come.

REFERENCES

EIA/IS 731, Systems Engineering Capability EIA/IS 731, EIA Interim Standard, Electronic Industries Association, 1998.

Ibrahim, Linda, et. al., The Federal Aviation Administration Integrated Capability Maturity Model (FAA-iCMM), Version 2.0, Federal Aviation Administration, September 2001. (available at www.faa.gov/aio)

Ibrahim, Linda, et. al., *The FAA-iCMM Appraisal Method (FAM), Version 1.0*, Federal Aviation Administration, April 1999. (available at www.faa.gov/aio)

ISO 9004:2000, ISO 9004:2000(E), Quality management systems – Guidelines for performance improvements, International Organization for Standardization, Second edition, 2000-12-15.

ISO/IEC TR 15504, ISO/IEC TR 15504:1998(E) Information technology – Software process assessment, Part 7: Guidelines for software process improvement, International Organization for Standardization and International Electrotechnical Commission, 1998.

Shull, Forrest, et al, "An Empirical Methodology for Introducing Software Processes," 8th European Software Engineering Conference and 9th ACM SIGSOFT Symposium on the Foundations of Software Engineering, Vienna, Austria, September 2001, pp.288-296.

BIOGRAPHIES

Curt Wells provides process improvement and training services through his company, I-metrics LLC. He is a co-author of the SE-CMM, EIA/IS 731, CMMI V1, and FAA iCMM V2. Curt retired from Lockheed Martin after 30 years service in various systems engineering and management roles. He holds a Masters degree in Physics from Sam Houston State University.

Linda Ibrahim joined FAA in 1996. She is FAA Chief Engineer for Process Improvement, providing technical leadership for FAA-wide process improvement. She led development of FAA-iCMM v1.0 and v2.0, and its appraisal method. Linda has been working in software engineering for over 30 years, as practitioner, educator, and researcher; in the US, Europe, and Middle East. She worked at the Software Engineering Institute for several years, and is a member of the CMMI Steering Group. Linda holds a BA in Mathematics, MS in Information Science, and Ph.D. in Electrical Engineering. She is a member of INCOSE, ACM, and IEEE.

Larry LaBruyere has been with TRW for over 19 years and supports the Federal Aviation Administration's Chief Information Officer on a technical assistance contract supporting process improvement based on the FAA-iCMM. He is the appraisal coordinator and a FAM appraisal lead for the FAA and participated in the authoring of the FAA-iCMM and FAM. Mr. LaBruyere is an "Authorized CBA IPI Lead Assessor" for the SW-CMM. He is an authorized instructor for Practical Software and Systems Measurement. He obtained an MS from American University, and a BA from Anderson University.

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